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(54) IMPROVEMENTS IN OR RELATING TO RAZOR BLADES

RASIERKLINGE

AMELIORATIONS CONCERNANT LES LAMES DE RASOIR

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Description

[0001] This invention relates to razor blades and to processes of forming razor blades with sharp and durable cutting edges.

[0002] A razor blade typically is formed of suitable substrate material such as metal or ceramic and an edge is formed with wedge-shape configuration with an ultimate edge or tip that has a radius of less than about 1,000 angstroms, the wedge shaped surfaces having an included angle of less than 30°. As shaving action is severe and blade edge damage frequently results and to enhance shavability, the use of one or more layers of supplemental coating material has been proposed for shave facilitation, and/or to increase the hardness and/or corrosion resistance of the shaving edge. A number of such coating materials have been proposed, Such as polymeric materials and metals, as well as other materials including diamond and diamond-like carbon (DLC) material. Each such layer or layers of supplemental material must have adhesion compatibility so that each layer remains firmly adhered to the substrate throughout the useful life of the razor blade, and desirably provide characteristics such as improved shavability, improved hardness and/or corrosion resistance while not adversely affecting the geometry and cutting effectiveness of the shaving edge. It has been proposed to provide the cutting edges of razor blades with improved mechanical properties by applying to the sharpened edge of the substrate a coating of diamond or diamond-like carbon (DLC) material. Such materials may be characterized as having substantial sp^3 carbon bonding; a mass density greater than 1.5 $grams/cm^3$; and a Raman peak at about 1331 cm^1 (diamond) or about 1552 cm^1 (DLC). However, such proposals have not been satisfactory due to the tendency of the diamond or diamond-like coating to have poor adhesion to and to peel off from the wedge-shaped edge of the substrate.

[0003] U.S. Patent 3,761,374 discloses a process for depositing a strengthening layer of metal or alloy material such as chromium or chrome-platinum upon a sharpened edge of a razor blade.

[0004] German Patent 3,047,888 discloses coating a tool or razor blade surface with a carbon layer having a diamond-like structure and with an interlayer of silicon or silicon dioxide,

[0005] It has now been found that an interlayer of molybdenum provides an excellent adhesion of the diamond or diamond-like carbon to the wedge-shaped edge of the substrate, but it has been found that under certain accelerated corrosion testing conditions such as immersion in hot distilled water at 80°C. for 16 hours, a diamond-like carbon coating can delaminate from a molybdenum interlayer and the steel blade substrate by what appears to be an electrochemical reaction.

[0006] The invention resides in a process of forming a razor blade which comprises providing a substrate, forming a wedge-shaped sharpened edge on the substrate having an included angle of less than 30 degrees, depositing an interlayer on the substrate, and depositing a layer of diamond or diamond-like carbon material on the interlayer so that the interlayer is between and in contact with the layer of diamond or diamond-like carbon material on the one side and with the substrate including its sharpened edge on the other side, characterized in that the substrate has a tip radius of less than twelve hundred angstroms and the interlayer consists of niobium.

[0007] The invention also resides in a razor blade which is the direct end product of the aforesaid process, comprising a substrate having a wedge-shaped edge with an included angle of less than 30 degrees, an interlayer on the substrate and a layer of diamond or diamond-like carbon material on the interlayer so that the interlayer is between and in contact with the layer of diamond or diamond-like carbon material on one side and with the substrate including its sharpened edge on the other, characterized in that the substrate has a tip radius of less than twelve hundred angstroms and the interlayer consists of niobium. The invention further resides in a shaving unit including one or more of such blades.

[0008] The blade exhibits excellent shaving properties and long shaving life.

[0009] Preferred embodiments are defined by the dependent claims.

[0010] The interlayer and the diamond or DLC layer may be deposited by various techniques such as plasma decomposition of hydrocarbon gases, sputter deposition using ions from either a plasma or an ion gun to bombard a target, directly using a beam of carbon ions, and ion bean assisted deposition (IBAD) process using either E-Beam or sputtering sources.

[0011] In a particular process, the substrate is mechanically abraded in a sequence of honing steps to form the sharpened edge; layers of niobium and diamond or diamond-like carbon material are successively deposited by sputtering; the niobium interlayer having a thickness of less than about five hundred angstroms, and the diamond or DLC coating on the niobium coated cutting edge having a thickness of at least about twelve hundred angstroms; the layer of diamond having a Raman peak at about 1331 cm^{-1} and the layer of diamond-like carbon (DLC) material having a Raman peak at about 1550 cm^{-1}; substantial sp3 carbon bonding; and a mass density greater than 1.5 $grams/cm^3$; and an adherent polymer coating is applied on the diamond or DLC coated cutting edge.

[0012] The shaving unit comprising a razor blade according to the invention may be of the disposable cartridge type adapted for coupling to and uncoupling from a razor handle or may be integral with a handle so that the complete razor is discarded as a unit when the blade or blades become dull. The front and rear skin engaging surfaces cooperate with the blade edge (or edges) to define the shaving geometry. Particularly preferred shaving units are of the types shown in U.S. Pat-

ent 3,876,563 and in U.S. Patent 4,586,255.

[0013] Other features and advantages of the invention will be seen as the following description of particular embodiments progresses, in conjunction with the drawings, in which:

Fig. 1 is a perspective view of a shaving unit comprising a razor blade in accordance with the invention;
Fig. 2 is a perspective view of another shaving unit comprising a razor blade in accordance with the invention;
Fig. 3 is a diagrammatic view illustrating one example of razor blade edge geometry in accordance with the invention;
Fig. 4 is a diagrammatic view of apparatus for use in the process in accordance with the invention; and
Figs. 5 and 6 are Raman spectra of DLC material deposited with the apparatus of Fig. 4.

Description of Particular Embodiments

[0014] With reference to Fig. 1, shaving unit 10 includes structure for attachment to a razor handle, and a platform member 12 molded of high-impact polystyrene that includes structure defining forward, transversely-extending skin engaging surface 14. Mounted on platform member 12 are leading blade 16 having sharpened edge 18 and following blade 20 having sharpened edge 22. Cap member 24 of molded high-impact polystyrene has structure defining skin-engaging surface 26 that is disposed rearwardly of blade edge 22, and affixed to cap member 24 is shaving aid composite 28.

[0015] The shaving unit 30 shown in Fig. 2 is of the type shown in Jacobson U.S. Patent 4,586,255 and includes molded body 32 with front portion 34 and rear portion 36. Resiliently secured in body 32 are guard member 38, leading blade unit 40 and trailing blade unit 42. Each blade unit 40, 42 includes a blade member 44 that has a sharpened edge 46. A shaving aid composite 48 is frictionally secured in a recess in rear portion 36.

[0016] A diagrammatic view of the edge region of the blades 16, 20 and 44 is shown in Fig. 3. The blade includes stainless steel body portion 50 with a wedge-shaped sharpened edge formed in a sequence of edge forming honing operations that forms a tip portion 52 that has a radius typically less than 500 angstroms with facets 54 and 56 that diverge at an angle of about 13°. Deposited on tip 52 and facets 54, 56 is interlayer 58 of niobium that has a thickness of about 300 angstroms. Deposited on niobium interlayer 58 is outer layer 60 of diamond-like carbon (DLC) that has a thickness of about 2,000 angstroms, with facets 62, 64 that have lengths of about one-quarter micrometer each and define an included angle of about 80°, facets 62, 64 merging with main facet surfaces 66, 68 that are disposed at an included angle of about 13° and an aspect ratio (the ratio of the distance (a) from DLC tip 70 to stainless steel tip 52 and the width (b) of the DLC coating 60 at tip 52) of about 1.7. Deposited on layer 60 is an adherent telomer layer 72 that has a substantial as deposited thickness but is reduced to monolayer thickness during initial shaving.

[0017] Apparatus for processing blades of the type shown in Fig. 3 is diagrammatically illustrated in Fig. 4. That apparatus includes a DC planar magnetron sputtering system manufactured by Vac Tec Systems of Boulder, Colorado that has stainless steel chamber 74 with wall structure 80, door 82 and base structure 84 in which is formed port 86 coupled to a suitable vacuum system (not shown). Mounted in chamber 74 is carousel support 88 with upstanding support member 90 on which is disposed a stack of razor blades 92 with their sharpened edges 94 in alignment and facing outwardly from support 90. Also disposed in chamber 74 are support structure 76 for target member 96 of niobium (99.99% pure) and support structure 78 for target member 98 of graphite (99.999% pure). Targets 96 and 98 are vertically disposed plates, each about twelve centimeters wide and about thirty-seven centimeters long. Support structures 76, 78 and 88 are electrically isolated from chamber 74 and electrical connections are provided to connect blade stack 92 to RF power supply 100 through switch 102 and to DC power supply 104 through switch 106; and targets 96 and 98 are connected through switches 108, 110, respectively, to DC magnetron power supply 112. Shutter structures 114 and 116 are disposed adjacent targets 96, 98, respectively, for movement between an open position and a position obscuring its adjacent target.

[0018] Carousel 88 supports the blade stack 92 with the blade edges 94 spaced about seven centimeters from the opposed target plate 96, 98 and is rotatable about a vertical axis between a first position in which blade stack 92 is in opposed alignment with niobium target 96 (Fig. 4) and a second position in which blade stack 92 is in opposed alignment with graphite target 98.

[0019] In a particular processing sequence, a stack of blades 92 (five centimeters high) is secured on support 90; chamber 74 is evacuated; the targets 96, 98 are cleaned by DC sputtering for five minutes; switch 102 is then closed and the blades 92 are RF cleaned in an argon environment for five minutes at a pressure of ten millitorr, an argon flow of 200 sccm and a power of 1.5 kilowatts; the argon flow is then reduced to 150 sccm at a pressure of 2.0 millitorr in chamber 74; switch 106 is closed to apply a DC bias of -25 volts on blades 92; switch 108 is closed to commence sputtering at one kilowatt power and shutter 114 in front of niobium target 96 is opened for thirty seconds to deposit a niobium layer 58 of about 300 angstroms thickness on the blade edges 94. Shutter 114 is then closed, switches 106 and 108 are opened, and carousel 88 is rotated 90° to juxtapose the blade edges of blade stack 92 with graphite

target 98. Pressure in chamber 74 is maintained at two millitorr with an argon flow of 150 sccm; switch 110 is closed to sputter graphite target 98 at 750 watts; switch 102 is closed to apply a 13.56 MHz RF bias of eight hundred watts (-420 volts DC self bias voltage) on blades 92, and concurrently shutter 116 is opened for twenty minutes to deposit a DLC layer 60 of about two thousand angstroms thickness on niobium layer 58. The DLC coating 60 had a radius at tip 70 of about 350 Angstroms that is defined by facets 62, 64 that have an included angle of about 80°, and an aspect ratio of about 1.9:1. As illustrated in Fig. 5, Raman spectroscopy of the coating material 60 deposited in this process shows a broad Raman peak 118 extending between about 1350 and 1530 cm^{-1} wave numbers, a spectrum typical of DLC structure.

[0020] A coating 72 of polytetrafluoroethylene telomer is then applied to the DLC-coated edges of the blades. The process involves heating the blades in a neutral atmosphere of argon and providing on the cutting edges of the blades an adherent and friction-reducing polymer coating of solid PTFE. Coatings 58 and 60 were firmly adherent to the blade body 50, provided low wet wool felt cutter force (the lowest of the first five cuts with wet wool felt (L5) being about 0.45 kilogram), and withstood repeated applications of wool felt cutter forces indicating that the DLC coating 60 is substantially unaffected by exposure to the severe conditions of this felt cutter test and remains firmly adhered to the blade body 50, even after immersion in 80°C. distilled water for sixteen hours. Resulting blade elements 44 were assembled in cartridge units 30 of the type shown in Fig. 2 and shaved with excellent shaving results.

Claims

1. A process of forming a razor blade which comprises providing a substrate (50), forming a wedge-shaped sharpened edge (52) on the substrate having an included angle of less than 30 degrees, depositing an interlayer (58) on the substrate, and depositing a layer (60) of diamond or diamond-like carbon material on the interlayer so that the interlayer is between and in contact with the layer of diamond or diamond-like carbon material on the one side and with the substrate including its sharpened edge on the other side, characterized in that the substrate has a tip radius of less then twelve hundred angstroms and the interlayer (58) consists of niobium.

2. A process according to claim 1, characterized by the fact that the interlayer (58) on the sharpened edge (52) has a thickness of less than about five hundred angstroms, and the diamond or diamond-like carbon layer (60) on the interlayer-coated sharpened edge has a thickness of at least twelve hundred angstroms from the sharpened edge of the substrate to a distance of forty micrometers from said edge.

3. A process according to claim 1 or 2, characterized by the fact that the substrate (50) is of metal and the diamond or diamond-like carbon layer (60) is at least twice as hard as said metal substrate.

4. A process according to any one of the preceding claims, characterized by the fact that the diamond or diamond-like carbon layer (60) is deposited in an argon atmosphere in an evacuated chamber (74) in which graphite and niobium targets (96,98) are located; the niobium target (96) is energized, and an interlayer (58) of niobium is deposited on the blade edge by sputtering, and the graphite target (98) is then energized to deposit a layer (60) of the diamond or diamond-like carbon material on the niobium layer while an RF bias is applied to the substrate (50).

5. A process according to any one of the preceding claims, characterized by the fact that the layer (60) of diamond or diamond-like carbon material has a radius at its ultimate tip of less than about four hundred angstroms.

6. A process according to any one of the preceding claims, characterized by the fact that the diamond or diamond-like carbon material layer (60) on the blade edge (52) has a thickness of about two thousand angstroms.

7. A process according to any one of the preceding claims, characterized by the further step of applying an adherent polymer coating (72) on the diamond or diamond-like carbon material coated sharpened edge (52).

8. A razor blade obtained as the direct end product of the process of any one of claims 1-7, comprising a substrate having a wedge-shaped edge with an included angle of less than 30 degrees, an interlayer on the substrate and a layer of diamond or diamond-like carbon material on the interlayer so that the interlayer is between and in contact with the layer of diamond or diamond-like carbon material on one side and with the substrate including its sharpened edge on the other, characterized in that the substrate has a tip radius of less than twelve hundred angstroms and the interlayer consists of niobium.

9. A razor blade according to claim 8, characterized by the fact that the layer (60) of diamond or diamond-like carbon material has a Raman peak at about 1331 cm^{-1} (diamond) or about 1552 cm^{-1} (DLC), an aspect ratio of less than about 3:1; substantial sp^3

carbon bonding; and a mass density greater than 1.5 grams/cm^3.

10. A shaving unit characterized by the fact that it includes one or more razor blades according to claim 8 or 9.

Patentansprüche

1. Verfahren zur Herstellung einer Rasierklinge, wobei das Verfahren folgendes umfaßt: die Bereitstellung eines Substrats (50); die Gestaltung einer keilförmigen, scharfen Kante (52) an dem Substrat mit einem Öffnungswinkel von weniger als 30 Grad; Auftragen einer Zwischenschicht (58) auf dem Substrat; und Auftragen einer Schicht (60) aus Diamant oder einem diamantartigen Kohlenstoff auf der Zwischenschicht, so daß sich die Zwischenschicht zwischen der Diamantschicht oder der diamantartigen Kohlenstoffschicht auf der einen Seite und in Kontakt damit befindet, und wobei das Substrat mit dessen scharfen Kante auf der anderen Seite vorgesehen ist; dadurch gekennzeichnet, daß das Substrat einen Spitzenradius von weniger als zwölfhundert Angström aufweist, und wobei die Zwischenschicht (58) Niobium umfaßt.

2. Verfahren nach Anspruch 1, gekennzeichnet durch die Tatsache, daß die Zwischenschicht (58) an der scharfen Kante (52) eine Dicke von weniger als etwa fünfhundert Angström aufweist, und wobei die Diamant- oder die diamantartige Kohlenstoffschicht (60) an der mit der Zwischenschicht beschichteten scharfen Kante eine Dicke von mindestens zwölfhundert Angström von der scharfen Kante des Substrats bis zu einer Entfernung von vierzig Mikrometern von der genannten Kante aufweist.

3. Verfahren nach Anspruch 1 oder 2, gekennzeichnet durch die Tatsache, daß das Substrat (50) aus Metall ist, und wobei die Diamantschicht oder diamantartige Kohlenstoffschicht (60) mindestens doppelt so hart ist wie das genannte Metallsubstrat.

4. Verfahren nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Diamantschicht oder die diamantartige Kohlenstoffschicht (60) in einer Argonatmosphäre in einer luftleeren Kammer (74) aufgetragen wird, in der sich Graphit- und Niobium-Targetelemente (96, 98) befinden; wobei das Niobium-Targetelement (96) erregt wird, und wobei eine Zwischenschicht (58) aus Niobium durch Sputtertechnik auf der Klingenkante aufgetragen wird, und wobei das Graphit-Targetelement (98) danach erregt wird, um eine Schicht (60) aus Diamant oder einem diamantartigen Kohlenstoff auf der Niobiumschicht aufzutragen, während dem Substrat (50) eine Hochfrequenzvorspannung zugeführt wird.

5. Verfahren nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Schicht (60) aus Diamant oder einem diamantartigen Kohlenstoff an ihrer äußersten Spitze einen Radius von weniger als etwa vierhundert Angström aufweist.

6. Verfahren nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Schicht (60) aus Diamant oder einem diamantartigen Kohlenstoff auf der Klingenkante (52) eine Dicke von etwa zweitausend Angström aufweist.

7. Verfahren nach einem der vorstehenden Ansprüche, gekennzeichnet durch den weiteren Schritt des Auftragens einer haftenden Polymerbeschichtung (72) auf die mit Diamant oder einem diamantartigen Kohlenstoff beschichteten scharfen Kante (52).

8. Rasierklinge, die das unmittelbare Endprodukt des Verfahrens nach einem der Ansprüchen 1 bis 7 ist, wobei die Rasierklinge folgendes umfaßt: ein Substrat mit einer keilförmigen Kante mit einem Öffnungswinkel von weniger als 30 Grad; eine Zwischenschicht auf dem Substrat und eine Schicht aus Diamant oder einem diamantartigen Kohlenstoff auf der Zwischenschicht, so daß sich die Zwischenschicht zwischen der Diamantschicht oder der diamantartigen Kohlenstoffschicht auf der einen Seite und in Kontakt damit befindet, und wobei das Substrat mit dessen scharfen Kante auf der anderen Seite vorgesehen ist; dadurch gekennzeichnet, daß das Substrat einen Spitzenradius von weniger als zwölfhundert Angström aufweist, und wobei die Zwischenschicht Niobium umfaßt.

9. Rasierklinge nach Anspruch 8, dadurch gekennzeichnet, daß die Schicht (60) aus Diamant oder einem diamantartigen Kohlenstoff einen Raman-Spitzenwert von 1331 cm^{-1} (Diamant) oder etwa 1552 cm^{-1} (diamantartiger Kohlenstoff), ein Längenverhältnis von weniger als etwa 3:1, eine wesentliche sp^3 Kohlenstoffbindung und eine Massedichte von mehr als 1,5 Gramm/cm^3 aufweist.

10. Rasiereinheit, dadurch gekennzeichnet, daß diese eine oder mehrere der Rasierklingen gemäß den Ansprüchen 8 oder 9 aufweist.

Revendications

1. Procédé de formation d'une lame de rasoir qui comprend la fourniture d'un substrat (50), la formation sur le substrat d'un bord tranchant en forme de coin (52) ayant un angle de dégagement inférieur à 30°, le dépôt d'une couche intermédiaire (58) sur le

substrat et le dépôt d'une couche (60) de diamant ou de matériau carboné analogue au diamant sur la couche intermédiaire de manière que la couche intermédiaire soit entre et en contact avec la couche de diamant ou de matériau carboné analogue au diamant d'un côté et avec le substrat y compris son bord tranchant de l'autre côté, caractérisé en ce que le substrat a un rayon d'extrémité inférieur à 1 200 Å et la couche intermédiaire (58) consiste en niobium.

2. Procédé selon la revendication 1, caractérisé par le fait que la couche intermédiaire (58) sur le bord tranchant (52) a une épaisseur inférieure à environ 500 Å, et la couche de diamant ou de carbone analogue au diamant (60) sur le bord tranchant recouvert par la couche intermédiaire a une épaisseur d'au moins 1 200 Å depuis le bord tranchant du substrat jusqu'à une distance de 40 µm dudit bord.

3. Procédé selon la revendication 1 ou 2, caractérisé par le fait que le substrat (50) est en métal et la couche de diamant ou de carbone analogue au diamant (60) est au moins deux fois plus dure que ledit substrat métallique.

4. Procédé selon l'une quelconque des revendications précédentes, caractérisé par le fait que la couche de diamant ou de carbone analogue au diamant (60) est déposée dans une atmosphère d'argon dans une chambre mise sous vide (74) dans laquelle sont situées des cibles de graphite et de niobium (96, 98), la cible de niobium (96) est excitée et une couche intermédiaire (58) de niobium est déposée sur le bord de la lame par pulvérisation cathodique, puis la cible de graphite (98) est excitée pour déposer une couche (60) de diamant ou de matériau carboné analogue au diamant sur la couche de niobium, tandis qu'une polarisation RF est appliquée au substrat (50).

5. Procédé selon l'une quelconque des revendications précédentes, caractérisé par le fait que la couche (60) de diamant ou de matériau carboné analogue au diamant a un rayon au niveau de son extrémité ultime inférieur à environ 400 Å.

6. Procédé selon l'une quelconque des revendications précédentes, caractérisé par le fait que la couche de diamant ou de matériau carboné analogue au diamant (60) sur le bord (52) de la lame a une épaisseur d'environ 2 000 Å.

7. Procédé selon l'une quelconque des revendications précédentes, caractérisé par l'étape supplémentaire d'application d'un revêtement de polymère adhérant (72) sur le bord tranchant (52) recouvert de diamant ou de matériau carboné analogue au diamant.

8. Lame de rasoir obtenue sous forme de produit final direct du procédé selon l'une quelconque des revendications 1 à 7, comprenant un substrat ayant un bord en forme de coin avec un angle de dégagement inférieur à 30°, une couche intermédiaire sur le substrat et une couche de diamant ou de matériau carboné analogue au diamant sur la couche intermédiaire, de sorte que la couche intermédiaire est située entre et en contact avec la couche de diamant ou de matériau carboné analogue au diamant d'un côté et avec le substrat y compris son bord tranchant de l'autre, caractérisée en ce que le substrat a un rayon d'extrémité inférieur à 1 200 Å et la couche intermédiaire consiste en niobium.

9. Lame de rasoir selon la revendication 8, caractérisée par le fait que la couche (60) de diamant ou de matériau carboné analogue au diamant a un pic Raman à environ 1 331 cm^{-1} (diamant) ou à environ 1 552 cm^{-1} (CAD), un rapport d'allongement inférieur à environ 3:1, une liaison du carbone sensiblement sp^3 et une masse volumique supérieure à 1,5 g/cm^3.

10. Unité de rasage caractérisée par le fait qu'elle comprend une ou plusieurs lames de rasoir selon la revendication 8 ou 9.

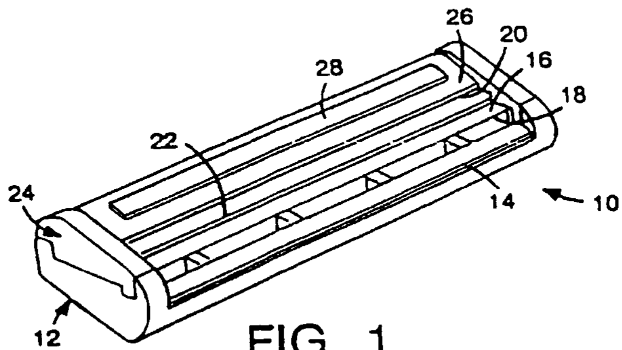

FIG. 1

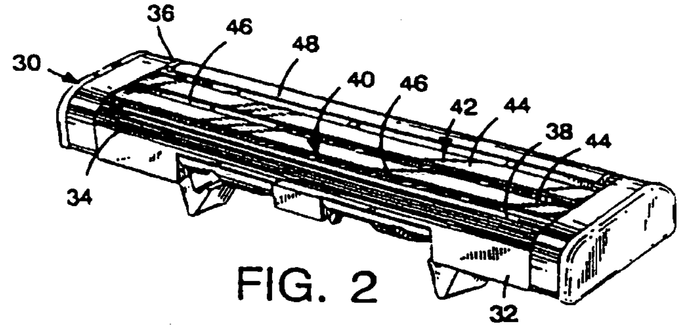

FIG. 2

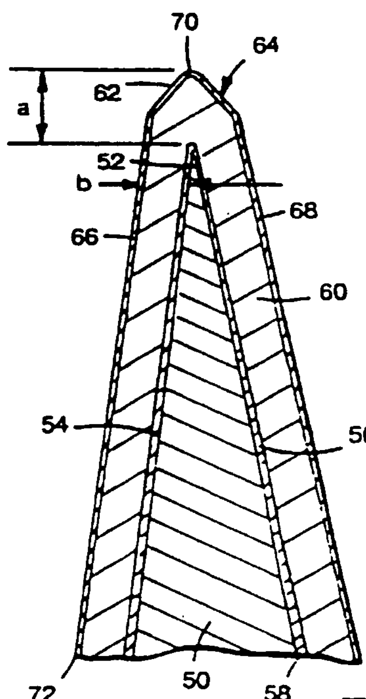

FIG. 3

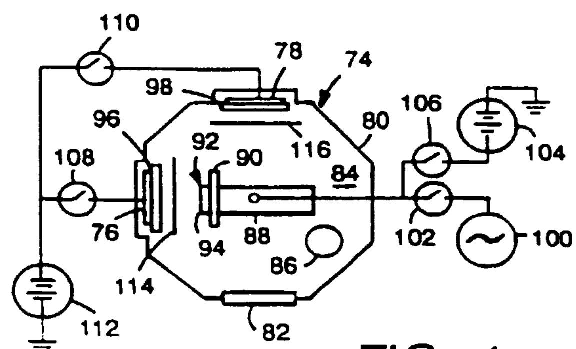

FIG. 4

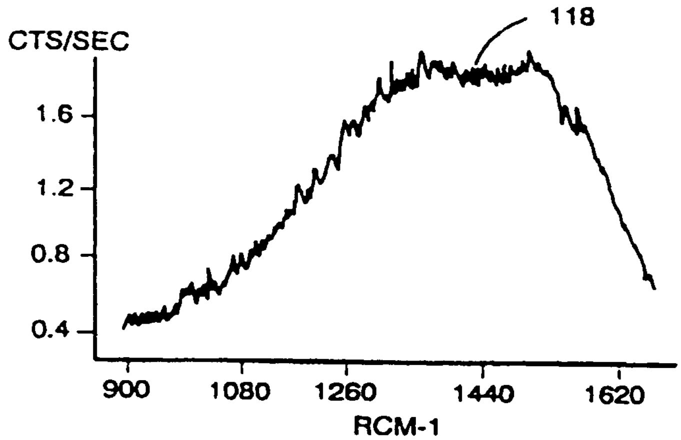
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FIG. 5

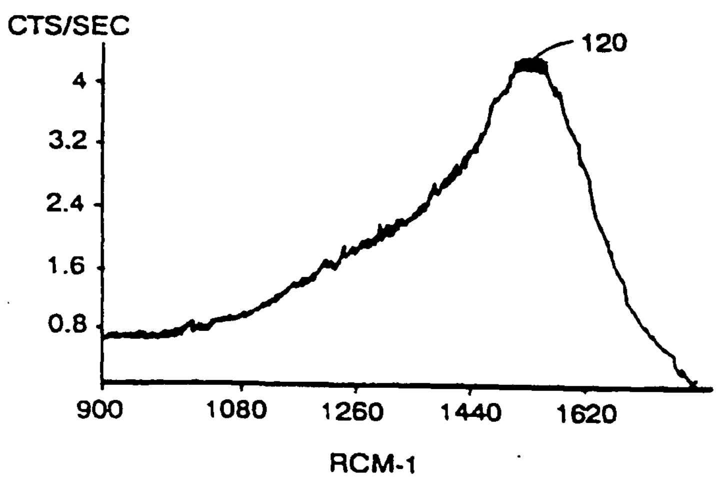
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FIG. 6